United States
Department of
Agriculture

Soil
Conservation
Service
Phoenix
Arizona

FLOOD PLAIN MANAGEMENT STUDY
for the
TOWN OF EAGAR
Apache County, Arizona

prepared by the

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
PHOENIX, ARIZONA

in cooperation with the

TOWN OF EAGAR
APACHE COUNTY
APACHE NATURAL RESOURCE CONSERVATION DISTRICT
ARIZONA DEPARTMENT OF WATER RESOURCES

JUNE 1986

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INTRODUCTION

Study Request

This study was requested by the Town of Eagar through the Apache Natural Resource Conservation District. Apache County and the Arizona Department of Water Resources have endorsed the effort.

The analyses were requested to provide more detailed information to regulate and manage the development within the flood plain areas. Developing areas within and adjacent to the town are lacking in flood plain definition. Existing flood insurance study data within the town (Reference 12) were developed using approximate methods. Except for the flood plain along the Little Colorado River, the data were not sufficiently detailed to provide information needed to most effectively use the flood plain and protect the users of these areas.

Local Input

The Town of Eagar has provided guidance and direction as the study has progressed. The town also provided topographic maps developed by photogrammetric methods (1979, Reference 2). Town personnel provided valuable input by furnishing estimates of building values and height from ground to first floor for the purpose of damage analysis.

Authorities

A plan of work was developed, approved and signed by sponsors in January 1984. Authorization was granted to perform the study by the Chief of the Soil Conservation Service on February 9, 1984.

The studies were performed by the Soil Conservation Service, USDA, under authorities set forth in Section 6, Public Law 83-566, Watershed Protection and Flood Prevention Act. Executive Order 11988, Floodplain Management, Section 1, with regulations contained in 7 CFR 650.25 instructs federal agencies regarding their responsibilities to avoid the risk of flood loss, minimize impacts and to restore and preserve the natural and beneficial values served by flood plains. A Unified National Program for Flood Plain Management, Water Resources Council, September 1979, provided for the acceleration of flood plain studies to assist state and local users.

Arizona Revised Statutes require communities to delineate and manage flood plains. These statutes give cities or towns the option of having their own flood plain management powers and duties or relinquishing them to a flood control district.

Technical Procedures

The studies resulting in this report and flood plain delineations were carried out using detailed procedures. Field investigations, field measurements from aerial mapping, available soils and land use data, and other information were gathered and compiled for inputting into SCS computer programs. Water surface

profiles were computed using the WSP2 program (Reference 8), the flood flow-frequency relationships were derived from the TR 20, Rainfall-Runoff Model (Reference 7). Damage analysis was made using the URB1, Urban Floodwater Damage Economic Evaluation Model (Reference 9).

Reliability of Results

Despite the detail, areas of shallow flooding (less than one foot) are not well defined. The effects of man-made barriers such as streets, ditches, low berms, fences, etc. which impede and/or divert flood flows make definition of flood paths extremely difficult, if not impossible. These conditions require that the flood plain boundaries and flood depth estimates at a specific point be interpreted and used with caution.

STUDY AREA DESCRIPTION

Location

The Town of Eagar is located in east-central Arizona in the southern extremities of Apache County. It lies at the foothills of the White Mountains adjacent to the town of Springerville. Eagar is about 170 air miles and 235 road miles east-northeast of Phoenix. It lies within the Little Colorado River Basin in the Lower Colorado River Region. The hydrologic unit number, which includes the study area, is 15020001010. Refer to map, Figure 1.

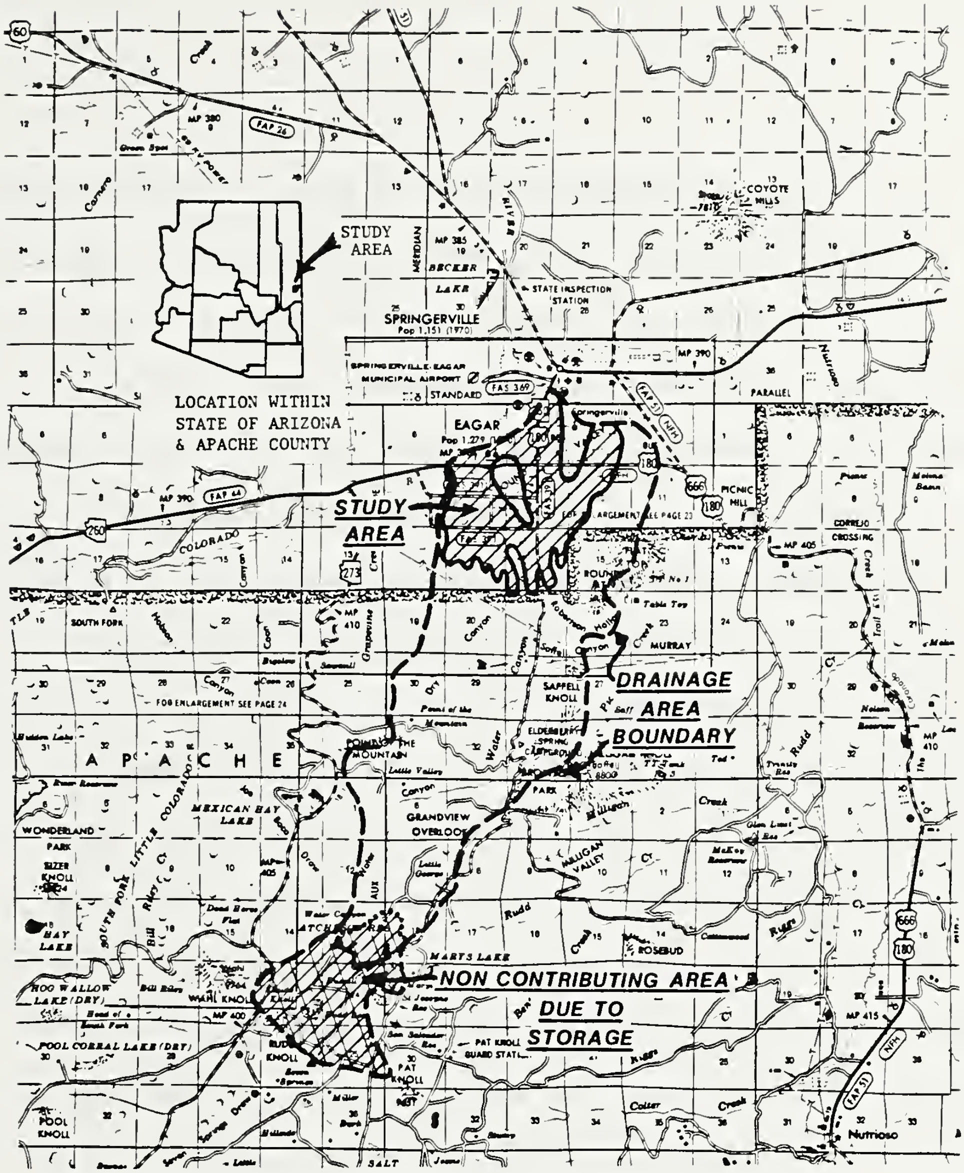

FIGURE 1: LOCATION MAP

Settlement History

In 1888 the Town of Eagar was established on land given by John, Joel and William Eagar. The Eagar brothers homesteaded in Round Valley around 1869. The 1985 population of the town is listed at 4001.

Climate

The town lies within the elevations of 7220 to 6990 feet above mean sea level. The highest point in the drainage area contributing runoff to the town is about 9300 feet above mean sea level. The lowest point, the Little Colorado River, is 6950. The drainage area lies within the White Mountains. Eagar gets the major part of its precipitation in the summer, with that in July, August and September accounting for more than sixty percent of the total for an average year. The summertime precipitation falls almost entirely during thunder storms which form in the moist, warm flow of air moving over Arizona from the Gulf of Mexico. The runoff produced from these storms causes the major floods within the study area. Winter precipitation comes largely from Pacific Ocean storms that have moved into the state from southern California. Since the moisture associated with these storms normally advances from the southwest, a large part of it falls as rain or snow over the steep slopes of the Mogollon Rim and the White Mountains before reaching Eagar. For this reason, Eagar does not have the marked secondary precipitation maximum in the winter that is characteristic of many Arizona stations.

Because of its altitude, nearly all of the precipitation occurring during December, January and February and the majority of that in November and March falls as snow. The normal annual precipitation is about 12 inches.

Winter temperatures are low. Temperatures as low as zero degrees F. have been recorded nearly every year since observations began, and about two out of five years record a temperature as low as ten degrees below zero. Summer weather

is characteristically warm afternoons and cool nights. Average maximum temperatures during the hottest part of the summer are in the low eighties and, on the average, the temperature reaches 95 degrees or more in only one summer out of ten. Indoor heating is sometimes required even during the summer months.

The average growing season extends only from the last week in May to the first week of October (Reference 11).

Soil Resources

The soils on these plains and low hills include about 45 percent identified as Clovis, 25 percent Palma, 10 percent Hubert and 20 percent Eagar, Sheppard, Millett, and Hereford soils. Where irrigated, Clovis and Hereford soils meet the criteria for prime farmland. Irrigated Eagar soils are considered additional farmland of statewide importance.

Clovis soils have a surface layer of brown loamy sand and a subsoil of reddish-brown sandy clay loam that is underlain by brown loamy sand and light-brown sandy loam. Palma soils have a surface layer of brown loamy sand, a subsoil of reddish-brown sandy loam, and underlying material of light-brown fine sandy loam. Hubert soils have a surface layer of brown gravelly loam and a subsoil of light brownish-gray gravelly loam that is underlain by white very gravelly loam and pinkish-white gravelly clay loam. All of these soils are more than 60 inches deep to bedrock (Reference 6).

Soils with high water conditions are encountered in the study area. Field investigations show that the soils mapped as Eagar loam and Fruitland loam on the flatter slopes, 1 to 3 percent, have the highest water tables. The water table is fed from natural subsurface flows originating from upland areas and from irrigation water applied to agricultural lands. These sources cause seasonal fluctuations in the water levels. The high water table conditions can increase surface runoff due to saturated soil conditions. This condition usually causes problems to anyone constructing buildings and, particularly, basements with the buildings. Septic tanks are also adversely affected.

Soils are used for range, irrigated farming, wildlife habitat and urban development. The major portion of the soils within the flood plain areas have moderate infiltration rates even when thoroughly wetted.

Drainage Areas and Length of Streams Studied

The study area was divided into four subareas: Robertson Hollow, covering 4.28 square miles; Eagar, 1.80 square miles; Water Canyon, 10.05 square miles; and Dry Canyon, 5.77 square miles. Water Canyon has a total drainage area of 13.8 square miles, but in the upper extremities there is extensive natural and manmade storage. Studies of the available storage led to the conclusion that the upper 3.75 square miles should be considered non contributing for this report. Refer to Fig. 1.

Channel analyses included 3.2 miles in Robertson Hollow area, 6.5 miles in Eagar, 3.1 miles in Water Canyon, and 4.4 miles in Dry Canyon.

NATURAL VALUES

Upland Vegetative Cover

The major part of the upland areas are in the Apache-Sitgreaves National Forest and are administered by the U.S. Forest Service, USDA. The vegetation of the contributing area lying within the national forest consists of the following (Reference 3).

Private land	7 percent
Pinyon-Juniper	32 percent
Grassland	6 percent
Ponderosa Pine	45 percent
Mixed conifer	10 percent

Land Uses in the 100 Year Flood Plain

The 100-year flood is estimated to inundate approximately 1180 acres (Refer to map in the back of the report). The uses of this flood plain area includes the following:

Residential-Commercial	29 percent
Lumber industry	3 percent
Cropland:	
Irrigated	28 percent
Nonirrigated	12 percent
Rangeland	11 percent
Pasture	11 percent
Channel	6 percent

Prime Farmland

Approximately 1430 acres of prime farmland exist in the area surrounding Eagar. About 770 acres (54 percent) of the prime farmland are subject to inundation by a 100-year flood. Residential and commercial developements already have encroached onto about 260 acres (18 percent) of the prime farmland.

Wildlife Resource Areas

Following is a description of vegetation and land use mapping units used to assess natural values of the study area, especially the wildlife resources. Please refer to the map in the back of the report.

Residential-Commercial: These areas, located essentially within the interior of Eagar, have experienced heavy tree planting for many years. The trees give aesthetic beauty to the town and also provide excellent nesting and roosting habitat to large numbers and kinds of birds. Shopping center areas and the lumber mill provide negligible components of habitat.

Scattered Urban/Rural Mixed: These small areas are located along Dry Canyon, Water Canyon and Robertson Hollow. Wildlife is plentiful along fence rows and water courses. Trees provide some habitat for birds which feed on insects in the fields and fence rows. Raccoon, cottontail rabbits, skunks and gophers are very common. Trout and crayfish are found in permanent water.

Irrigated-Subirrigated Pastures/Cropland: Apple and stone fruit orchards, corn fields, alfalfa, pasture grasses, gardens and native vegetation pastures provide a wealth of seed, fruit and forage for wildlife. The areas along the Little Colorado River provide seasonal habitat for wading birds and waterfowl in addition to livestock forage. Refer to Fig. 2.

Fig. 2

Water Canyon Outlet into Little Colorado River

Looking south-southeast at Water Canyon Channel and its flood plain. The Little Colorado River is in foreground

Pinyon-Juniper Lined Dry Washes: These areas, located in the upper reaches of the study area of Dry Canyon and Robertson Hollow, have no reliable water supply. Pinyon and juniper grow well along these washes because of the extra moisture occasionally available. These washes serve as travel lanes for wildlife of various kinds and also provide nesting and shade.

Riparian Streams and Wet Areas: These areas include Water Canyon, the lower reaches of Dry Canyon and the Little Colorado River. They support cottonwood, willow, redosier dogwood and other trees and shrubs and are the only places in the study area that such assemblages of plants are found. This habitat supports large numbers of perching birds, amphibians, and small mammals. These plants also contribute to stream quality by shading the water. The cottonwood along these streams are preferred by many recreationists and can be rehabilitated easier than vegetation along dry washes.

Blue Grama-Juniper Rangeland: These areas, located along the lower foothills around the edge of the study area, especially in the Dry Canyon and Robertson Hollow drainage are preferred by jackrabbits and prairie dogs. Consequently, coyotes and bobcats will also be found looking for these animals. Antelope may be seen occasionally. These areas provide some forage for domestic animals. The amount of forage depends upon the useable precipitation.

Pinyon-Juniper Uplands: These are the upland parts of the study area. Oak and other browse species are scattered in this vegetative type. Deer are usually found in this area. Birds, especially those that feed on pinyon nuts and juniper berries, are found in certain seasons. Coyotes feed on juniper berries and an occasional black bear may be found foraging for both nuts and berries.

This area is attractive for real estate development but because of steep slopes it is highly erodible and requires careful use.

Historic and Prehistoric Sites: Important historic and prehistoric sites have been identified within the study area. They are not considered to be in danger of significant damage due to flooding but must be carefully considered in any alterations due to flood plain management actions.

Flood History

The most frequent complaints of flooding come from the town area which receives flood water originating above the lumber mill, from Robertson Hollow, and local runoff. One of the larger and more recent floods resulted from an intense thunderstorm over these areas on July 25, 1983. This flood described as "...a tremendous amount of water down through town on Butler and Eagar Streets, which are the two North-South streets East of Main, and also from the sawmill down through Poverty Flats which is the east side of town. The first flood was the most severe. There was at times an area two blocks wide with 10 to 15 inches of water running through lots, roads and anything in its way. Since then we have had two more storms that caused flooding but less severe...." (Reference 10).

Fig. 3
SE Part of Eagar, Sept. 1984 Flood
Typical flooding along Butler Street

Other recent floods noted and documented by photographs include September 3, 1982, and Labor Day September 1984. Interviews indicate a degree of flooding occurring with the following frequency:

Location	Time that Resident has Lived at this Location (Yrs)	Number of Times Flooded to some Degree
Main, betw 7th & 8th st.	5	1
7th st. & Eagar	47	4 in last 10 yrs
8th st. & Butler	5	3 in last 2 yrs.
Butler, betw 5th & 6th st.	8	4
Butler, betw 5th & 6th st.	3	7
Central & Butler	4	3
Eagar, betw 2nd & 3rd st.	16	3
Eagar, betw 5th & 6th st.	4	1

Fig. 4

SE Part of Eagar, Sept. 1984 Flood
Shows shallow type flooding along Butler
Street between 5th and 6th streets.

Areas Inundated by 100 Year Flood

It is estimated that within the study area the 100 year flood will cover the following areas (acres):

Stream/Area	Farm Land *	Total
Dry Canyon	120	180
Water Canyon	238	325
Town of Eagar	36	380
Robertson Hollow	215	287
	609	1180

* Includes Irrigated Cropland, Nonirrated Cropland, Pasture

Properties Affected and Estimated Damage

The 100-year flood is expected to affect the following properties:

Stream/Area	Type of Building or Property					
	Yards	Houses or Apartments	Storage Buildings	Commercial Buildings	Public Buildings	Mobile Homes
Dry Canyon	11	6	4	0	0	3
Water Canyon	41	20	16	0	0	7
Town of Eagar	106	41	13	4	2	2
Robertson Hollow	14	5	11	0	0	4
TOTALS	172	72	44	4	2	16

The 100-year flood damage is estimated between $546,000 and $671,000. The average annual damage is expected to be between $111,000 and $144,000.

EXISTING FLOOD PLAIN MANAGEMENT

State and Local Regulations

Arizona Revised Statutes (ARS) require communities to delineate and manage flood plains. The statutes particularly addressing these requirements are ARS 45-2341 through 45-2909.

The Town of Eagar has adopted regulations through Flood Plain (Damage Prevention) Ordinance, Ordinance No. 100. Development permits are required before construction or developments begin within any area of special flood hazard as defined by the existing flood insurance rate map.

Public Participation

A meeting was held on August 26, 1983 with the Town of Eagar personnel. The purpose and uses of the study were explained and the scope of the study was determined.

ALTERNATIVES FOR FLOOD PLAIN MANAGEMENT

Present Condition

Housing developments are taking place in three general areas of Eagar. Recently most of the developments have been in the southeast part of town, east of Butler street and south of Central, along the edge of the Robertson

Hollow area. A second area is in the south central part, south of School Bus Road and west of Water Canyon Road, and lying along Water Canyon. The third area is in the southwest part of town where scattered housing has been constructed along Dry Canyon and in its tributaries.

Damages can be expected to increase in the future simply as a result of installing more structures. The degree of increase in damages will depend on the success of informing the public about the hazards relative to flooding and erosion and their response.

Land Treatment

In the lower portion of the watershed area, particularly the Robertson Hollow and Dry Canyon drainages, there is a need for land treatment. The pinyon-juniper areas shed a relatively large amount of water.

The Water Canyon watershed is in reasonably good condition. The upper portion is in good condition, but the lower part, the pinyon-juniper areas, needs treatments.

Currently, practices of range allotment and timber sales management are the methods used by the U.S. Forest Service to reduce runoff and erosion in balance with use. Road closure may be an added practice in the future to better manage the areas. Severe budget constraints make it doubtful that any significant changes in treatment will occur.

Preservation and/or Restoration of Natural Values

Preservation of wildlife habitat can result if development is allowed in a planned way. If zoning and/or building codes limits the removal of vegetation along the defined water courses, particularly Water Canyon and Dry Canyon, the habitat can be preserved.

Areas along water courses can be best used for recreation where facilities can be constructed to withstand flood flows. Preservation and development of flood plain areas can be compatible with the proper fitting of developments into the resource area with minimal disturbance.

Nonstructural Measures

The role of regulation can be effective in those areas that are not currently developed. This would especially apply to much of the Robertson Hollow flow areas and the lower reaches of Water Canyon and Dry Canyon. Zoning of the flood prone areas presents a method to prevent or reduce damages. The present city ordinance provides that potential buyers are notified that property is in an area of special flood hazard. This ordinance, aided by the results of this study, can be very effective to protect potential buyers.

It is recommended that the existing ordinances be reviewed to assure that adequate provisions have been made for flood proofing and building material restrictions.

Flood warning systems do not appear to be an option. The time lapse between identifying the imminent flooding and the occurrence of damaging flood conditions, less than an hour, is insufficient to allow for adequate response.

Flood proofing may be a feasible solution but a benefit-cost analysis was not performed. Since there are a large number of buildings involved, special considerations are necessary. Group flood proofing such as using walls or dikes may be the most feasible, but the impact upon adjacent areas would have to be carefully considered. Individual flood proofing usually causes the least impact upon adjacent areas, but again, would require special considerations.

Structural Measures

Opportunities of reducing flood losses by structural means are limited by the benefits resulting from the installation costs.

Limited studies indicate that the most feasible structural solution considered would be to: (1) Install a diversion channel upslope and parallel to the Big Ditch irrigation channel, and convey the floodwater eastward into the Robertson Hollow area; (2) Construct a dike to prevent overflow back toward the developed part of Eagar; and (3) Construct a diversion channel along U.S. Highway 180, install culverts under the highway, and build a dike along the east edge of existing housing developments. This solution may also require purchase of flood easements in lieu of construction and land rights for a continuous grassed waterway. Installation of this alternate would require coordination with the Town of Springerville. Refer to Figure 5.

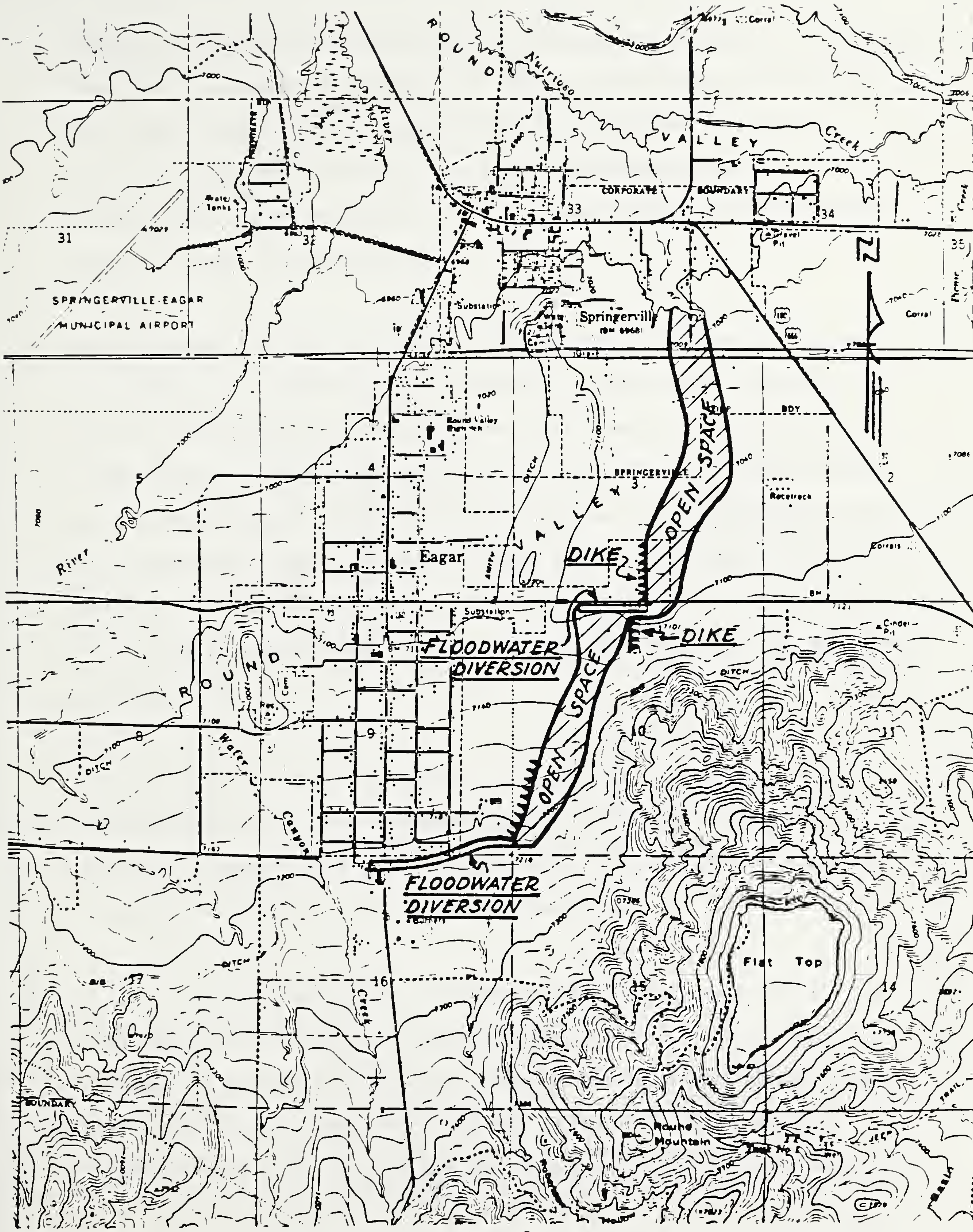

Fig. 5
Structural Alternative: Floodwater Diversion, Dikes and Open Space

Another structural alternative would be to install the diversion channel along Big Ditch, diverting the floodwater to the east and conveying the water in a continuous grassed waterway equipped with drop structures, to Nutrioso Creek. This alternatative would also require coordination with Springerville. Refer to Figure 6. It is doubtful that the benefits would support the high installation costs.

An additional structural alternative considered would involve installing a diversion channel along Big Ditch and diverting flood runoff from Robertson Hollow, above Big Ditch, to the west into Water Canyon. Then constructing a stable channel, probably a grassed waterway, down the Water Canyon drainage way and discharging into the Little Colorado River. This alternative would have more adverse impacts upon the wildlife habitat and wetlands than any of the other alternatives examined. Refer to Figure 7. This alternative would involve constructing several road crossings causing total costs to exceed the benefits derived.

Another alternative briefly examined, included constructing a floodwater retarding structure on Water Canyon upstream from School Bus Road. Refer to Figure 8. This was quickly ruled out because of limited storage capacity, high costs to install and relatively few benefits.

In 1981 the Arizona Department of Water Resources (ADWR) made a pre-reconnaissance investigation to determine the economic potential of implementing structural solutions to control flooding within the Dry Canyon area. Two structural plans were evaluated. Plan A included installing a floodwater retention structure upstream of Big Ditch to reduce the peak flow

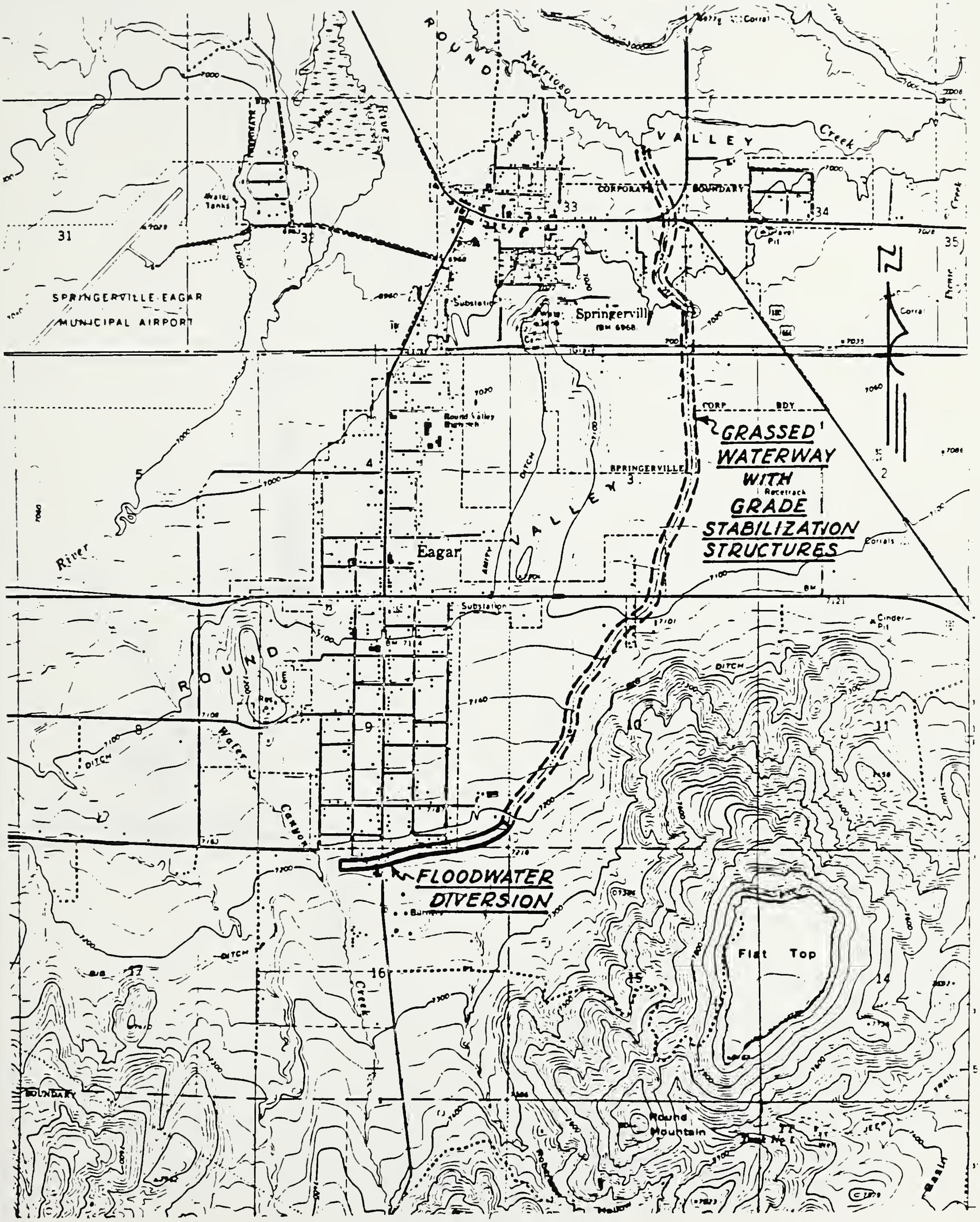

Fig. 6
Structural Alternative: Floodwater Diversion, Grassed Waterway with Grade Stabilzation Structure

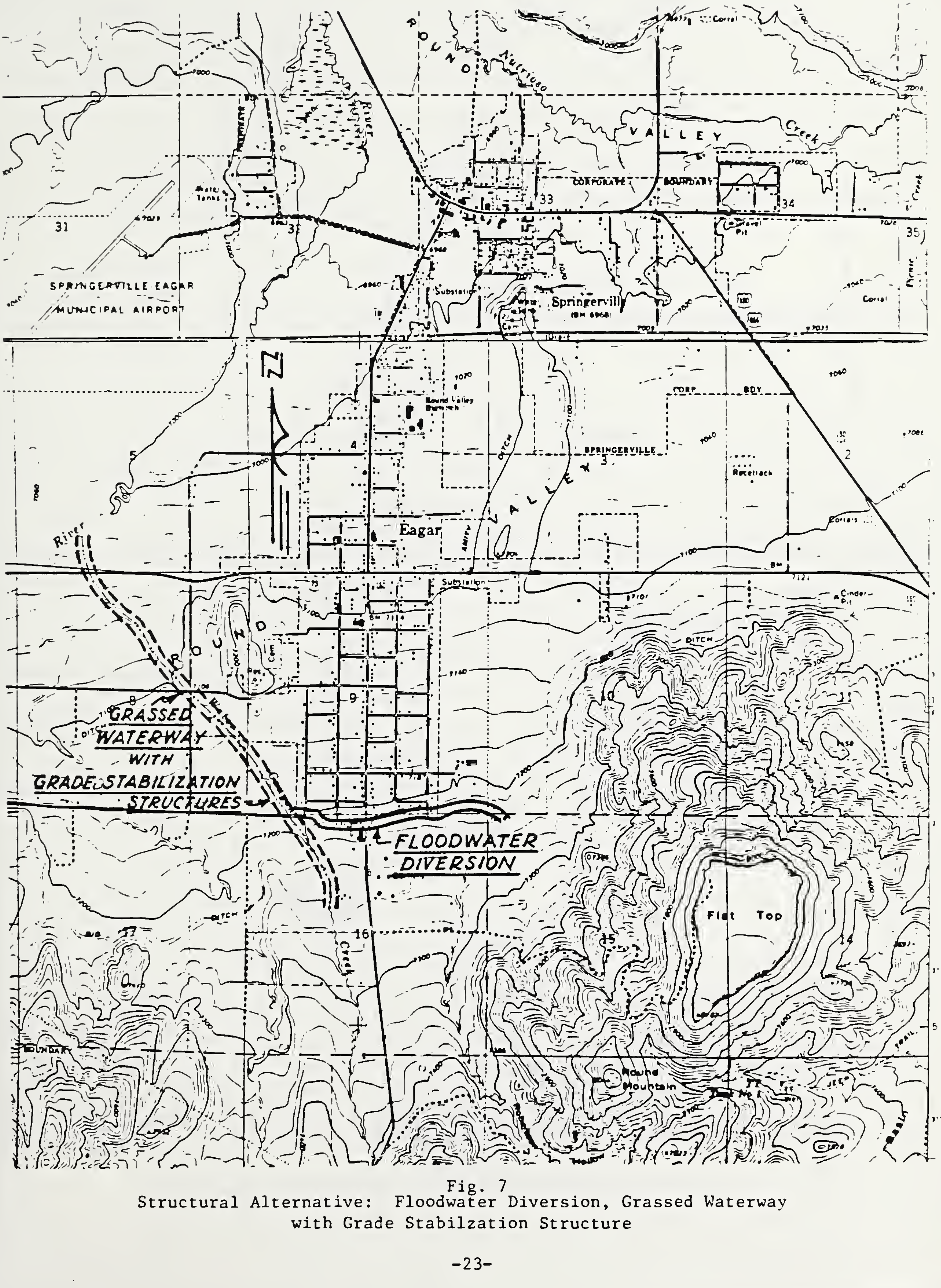

Fig. 7
Structural Alternative: Floodwater Diversion, Grassed Waterway with Grade Stabilzation Structure

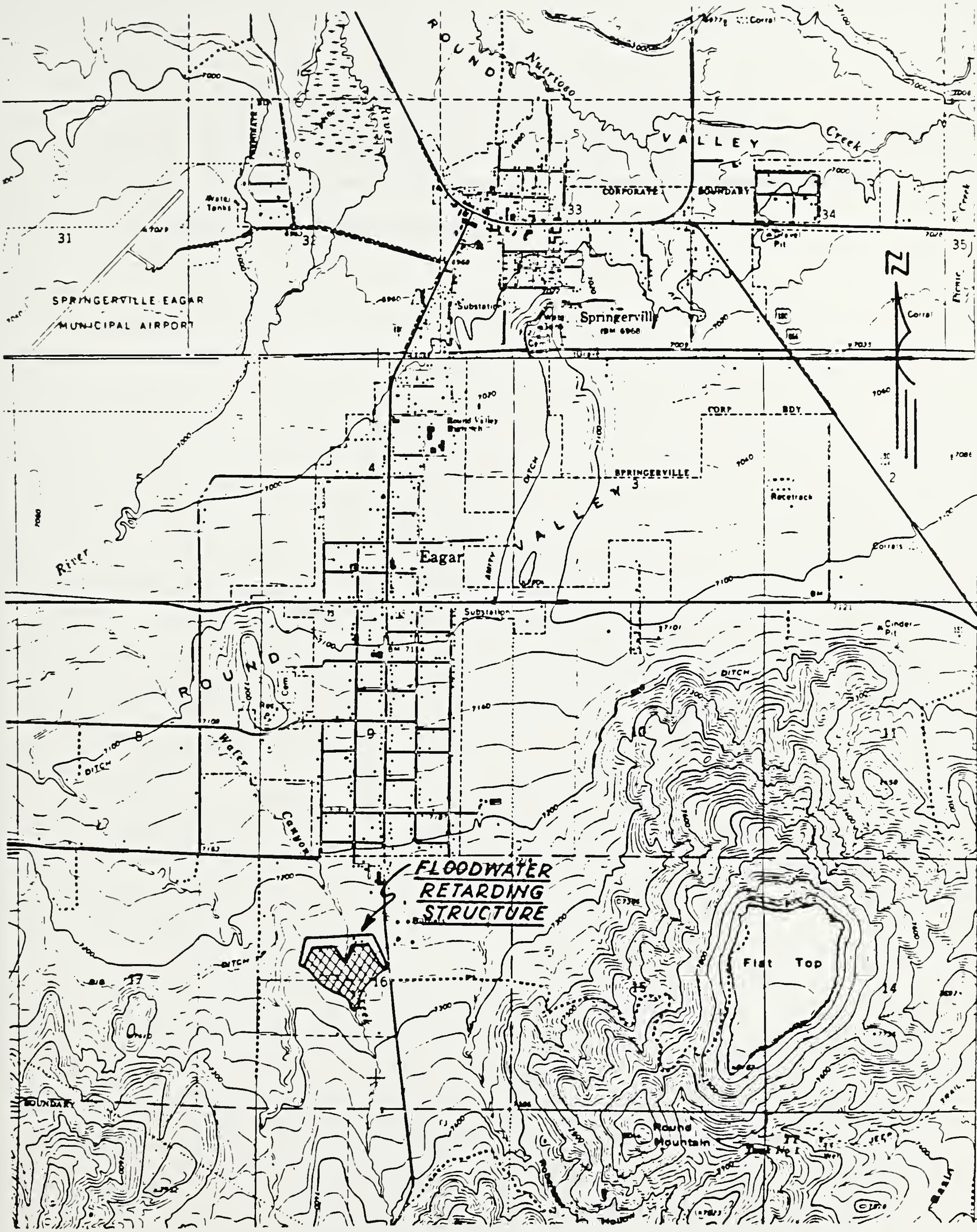

Fig. 8
Structural Alternative: Floodwater Retarding Structure

to a level that could be contained within the existing downstream channel. Plan B consisted of constructing a channel system from Big Ditch to School Bus Road. Neither plan showed a favorable benefit-cost relationship and ADWR could not recommend further studies (Reference 1).

GLOSSARY OF TERMS

cfs — cubic feet per second. A unit of~water flow.

conservation practices — Techniques or measures used to meet specific needs in planning and carrying out soil and water conservation programs for which standards and specifications have been developed.

cross section — A profile of the land surface taken at right angles to the direction of flow; made by measuring the elevation and distance at ground points along the selected line.

drainage area — The area draining into a stream at a given point (also watershed, drainage, catchment basin).

drainageway — A conveyance struture to remove water (channel).

flood — An event where a stream overflows its normal banks.

<u>flood plain</u>	The land adjacent to a body of water which has been or may be hereafter covered by flood water.
<u>flood frequency</u>	An expression or measure of how often a flood event of a given size or magnitude should on the average, be equaled or exceeded. For example a 100-year frequency flood should be equaled or exceeded in size, on the average, only once in 100 years (also recurrence interval, return period).
<u>flood profile</u>	A graph or a longitudinal profile showing the relationship of the water-surface elevation of a flood event to location along a stream or river.
<u>flood proofing</u>	A combination of structural provisions, changes, or adjustments to properties and structures subject to flooding primarily for the reduction or elimination of flood damages to properties, water and sanitary facilities, structures, and contents of buildings in a flood-hazard area.

flood warning — A community or locally based system consisting of volunteers; rainfall, river and other hydrologic gages; hydrologic models or procedures; a communication network; and a community or local flood coordinator responsible for issuing advance information relative to potential flooding.

indigenous life — Life having originated in and being produced, growing or living naturally in a particular region or environment.

hydraulics — The science that treats water in motion.

hydrology — The science that deals with the occurrence and behavior of water in the atmosphere, on the ground and underground.

land treatment — The application of conservation practices to reduce soil and water related resource problems associated with floodwater, erosion and sediment, and to further the conservation, development, utilization, and disposal of water and the conservation and utilization of land, thereby preserving, protecting, and improving the nation's land and water resources and the quality of the environment.

M^2 — Square miles; a unit of area.

overland flow — runoff which flows over the ground surface in a shallow layer as opposed to channelized flow.

peak discharge — The maximum discharge or rate of flow during a flood at a given location.

peak flood elevation — The highest stage or elevation reached by a flood at a given location.

prime farmland	Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, and oilseed crops, and is also available for these uses; includes cropland, pastureland, rangeland, forest lands, but not urbanized land or water; it has the soil quality, growing season, and moisture supply needed to produce sustained high yields of crops economically when treated and managed, including water management, according to modern agricultural methods.
riparian vegetation	The vegetated area and biotic community influenced by high water tables adjacent to streams and other surface waters.
routing	Determining the changes in a flood wave as it moves downstream through a flood plain or reservoir.
runoff	That portion of precipitation which contributes to flow in a channel or across the land surface (excess rainfall).

REFERENCES

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3. Forest Service, USDA; Letter to Robin P. McArthur, Water Resources Planning Staff, SCS-USDA, from Jerry Colmer, Apache-Sitgreaves National Forest; (about May 1985).

4. National Weather Service, NOAA, USDA; NOAA Atlas No. 2, Precipitation-Frequency Atlas of the Western United States, Volume VIII - Arizona; 1973.

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7. Soil Conservation Service, USDA; Technical Release No. 20, Computer Program for Project Formulation Hydrology; May 1983 (Draft Revision).

8. Soil Conservation Service, USDA; Technical Release No. 61, WSP2 Computer Program; May 1976.

9. Soil Conservation Service, USDA; Urban Floodwater Damage Economic Evaluation (URB1) Computer Application Program; January 1982 (Draft).

10. Town of Eagar; Letter to Harry C. Millsaps, Water Resources Planning Staff, SCS, USDA, from Gordon C. Henrie, Town Manager; August 17, 1983.

11. University of Arizona, Tucson; Arizona Climate, 1931-1972; Editors, William D. Sellers and Richard H. Hill; Revised 2nd Edition, Copyright 1974.

12. Federal Emergency Management Agency; Flood Insurance Study, Town of Eagar, Arizona, Apache County; July 6, 1981.

FLOOD HAZARD MAP

The Flood Hazard Map, showing boundaries of the 100-year flood, is found in the folder in the back of this report.

Where the mean depth of flow is one foot or less no flood elevations are shown. These areas include the Dry Canyon tributaries; zones within the heavily developed areas of Eagar, including the lumber mill; and the Robertson Hollow drainage, below Big Ditch.

Peak flow estimates, flood profiles for parts of the flood plain, and representative cross-sections with water surface elevations for the 500-, 100-, 50, and 10-year floods are presented in the Technical Appendix.

The flooded areas were derived neglecting the effect of sediment and debris that might be conveyed in the floodwaters. The effect of Big Ditch upon flow diversion and overtopping was taken into account using best judgment, tempered with limited historical data.

TECHNICAL APPENDIX

INVESTIGATIONS AND ANALYSES

Hydraulic and hydrologic studies were performed to derive water surface elevation and frequency estimates. These provided data for mapping flood boundaries and to estimate damages by size of flood. Field inventories of natural flood plain values were also carried out.

Hydraulic Studies

The basic land survey data was provided by the Town of Eagar. This included topographic maps developed in 1979 by photogrammetric methods, scale 1:2400 and 2 feet contour interval (Reference 2). Cross-sectional and profile data were taken from this source by the aerial mapping company that performed the original work.

Field surveys were made of pertinent constrictions including bridges, culverts and key irrigation ditches. The field measurements were tied to the topographic mapping.

Field mapping also was used to determine roughness coefficients and to determine the general route of frequent floods within the more intensely developed areas of the town.

Hydraulic computations were made using the SCS computer program, WSP2 (Reference 8). This analysis provided the basic rating relationship of elevation-discharge at each cross-section.

Hydrologic Studies

Since no streamflow data were available for the study area, a simulation model was used to derive estimates of peak flow-frequency relationships. The SCS TR-20 computer program, a rainfall-runoff model, was used.

The following input data and their sources were developed for this computer program:

Input Data	Source
Drainage Areas	USGS 7.5 minute quadrangle map and the 1:2400 topographic maps
Hydrologic Soil-Cover Complexes (curve number)	Forest Service, USDA, provided this information for all lands within the National Forest. (Reference 3) Other land areas: Soils from SCS published report (Reference 6). Vegetative cover from natural flood plain inventory data, SCS NEH, Sec. 4, (Reference 5)
Times of Concentration	Estimated from profiles taken from USGS 7.5 minute quadrangle sheets and visual judgments of channel cross-sections.
Channel Flood Routing	Taken from WSP2 output relating elevation-discharge-area for selected cross-sections
Precipitation	NOAA Atlas No. 2, Volume VIII - Arizona (Reference 4).
Storm Distribution	SCS Type II, 24-hour duration

The results of the peak flow estimates for selected frequencies and locations are shown in Table 1.

Following Table 1 are flood profiles for the better defined streams and associated overflow areas; profiles of the 500-, 100-, 50- and 10-year floods; and typical cross-sections to show the depth of flooding expected in the various flood plain locations along with the depths expected for the 100-year flood.

Damage Studies

Damage studies were made to assess the need and opportunity to take action to reduce the hazards of flooding. Output from the hydraulic and hydrologic studies were used in the URB1 computer program (Reference 9). The Town of Eagar provided inventory data of building values within the flood plain and of height from ground to first-floor elevation for each building.

General damage coefficient data was used in lieu of developing more site specific data.

Inventory of Natural Flood Plain Values

Field examination and data search provided information on wildlife, historic and prehistoric resources. Mapping units were used to make the inventory and describe the results. Refer to the appropriate sections in the the report, and the map in the back of the report.

TECHNICAL TABLES

Following are peakflow estimates for selected frequencies and specified locations:

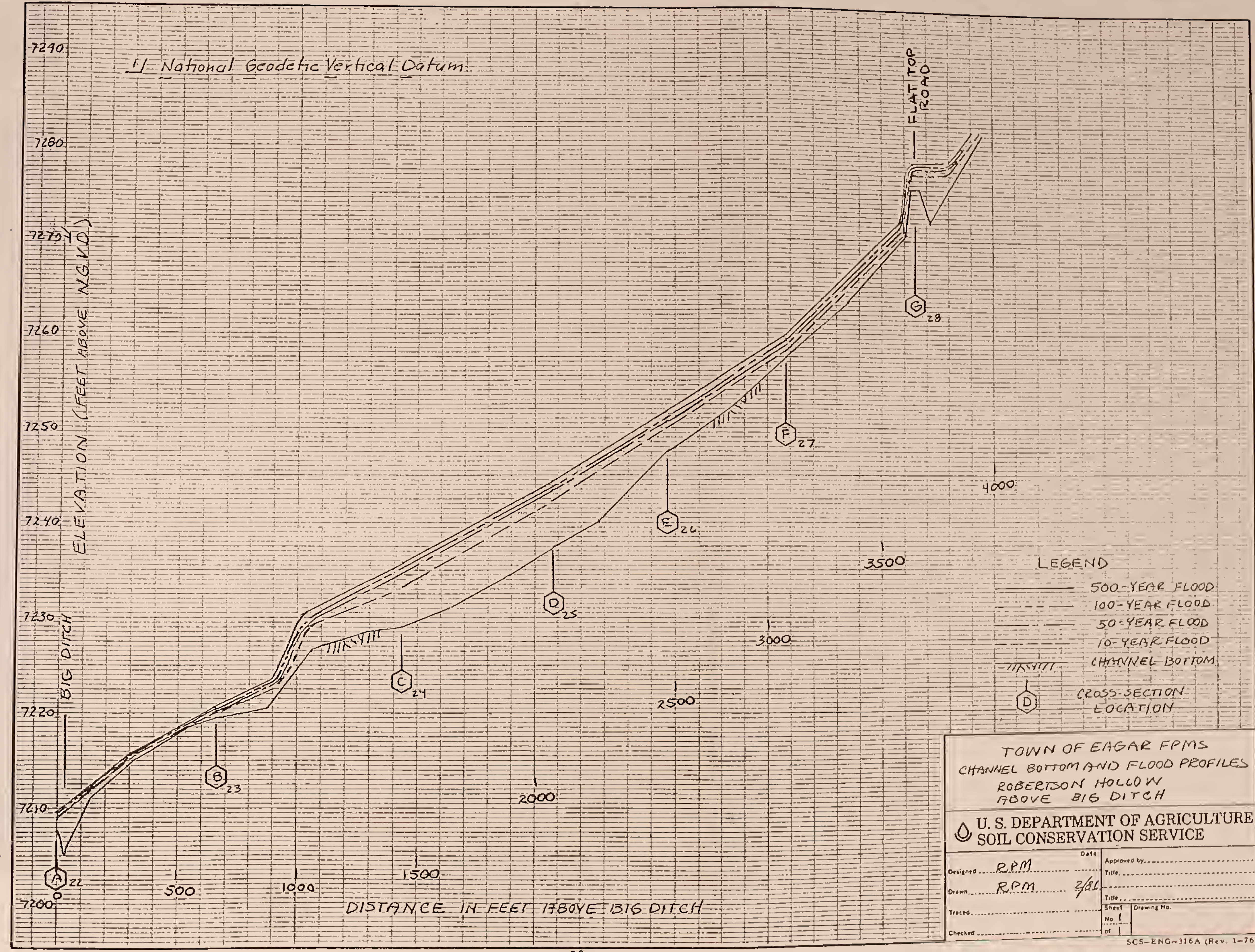
Table 1 - Peak Dscharges

Flooding Source and Location	Drainage Area (M^2)	Peak Discharges(cfs) 10-year	50-year	100-year	500-year
Robertson Hollow above Big Ditch	1.38	630	1130	1390	1990
Robertson Hollow at US Highway 180					
west part of flow	0.27	170	310	360	500
east flow, nr Proverty Flat Rd.	2.02	720	1450	1640	2440
Above Lumber Mill at Big Ditch	0.38	90	200	220	320
Within developed town					
Central, West of Main	0.18	70	140	170	250
Central, east of Main	0.66	100	380	560	980
Water Canyon					
at School Bus Rd.	9.20	530	1260	1660	2780
at 4th Street	9.54	510	1210	1620	2730
Dry Canyon					
at Spanish Trail	3.93	760	1730	2250	3460
at School Bus Rd.	5.52	1010	2090	2690	4030
at 4th Street	5.77	730	1790	2370	3770
Dry Canyon Tributary at Amity Lane	0.92	370	700	870	1260

USDA

Fold-out Placeholder

This fold-out is being digitized, and will be inserted at a future date.



1/ National Geodetic Vertical Datum
ELEVATION (FEET ABOVE NGVD)
7290
7280
7270
7260
7250
7240
7230
7220
7210
7200
BIG DITCH
FLAT TOP ROAD
A 22
B 23
C 24
D 25
E 26
F 27
G 28
0
500
1000
1500
2000
2500
3000
3500
4000
DISTANCE IN FEET ABOVE BIG DITCH
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
CROSS-SECTION LOCATION
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
ROBERTSON HOLLOW
ABOVE BIG DITCH
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed RPM
Drawn RPM 2/81
Traced
Checked
Date
Approved by
Title
Sheet No. 1 of
Drawing No.
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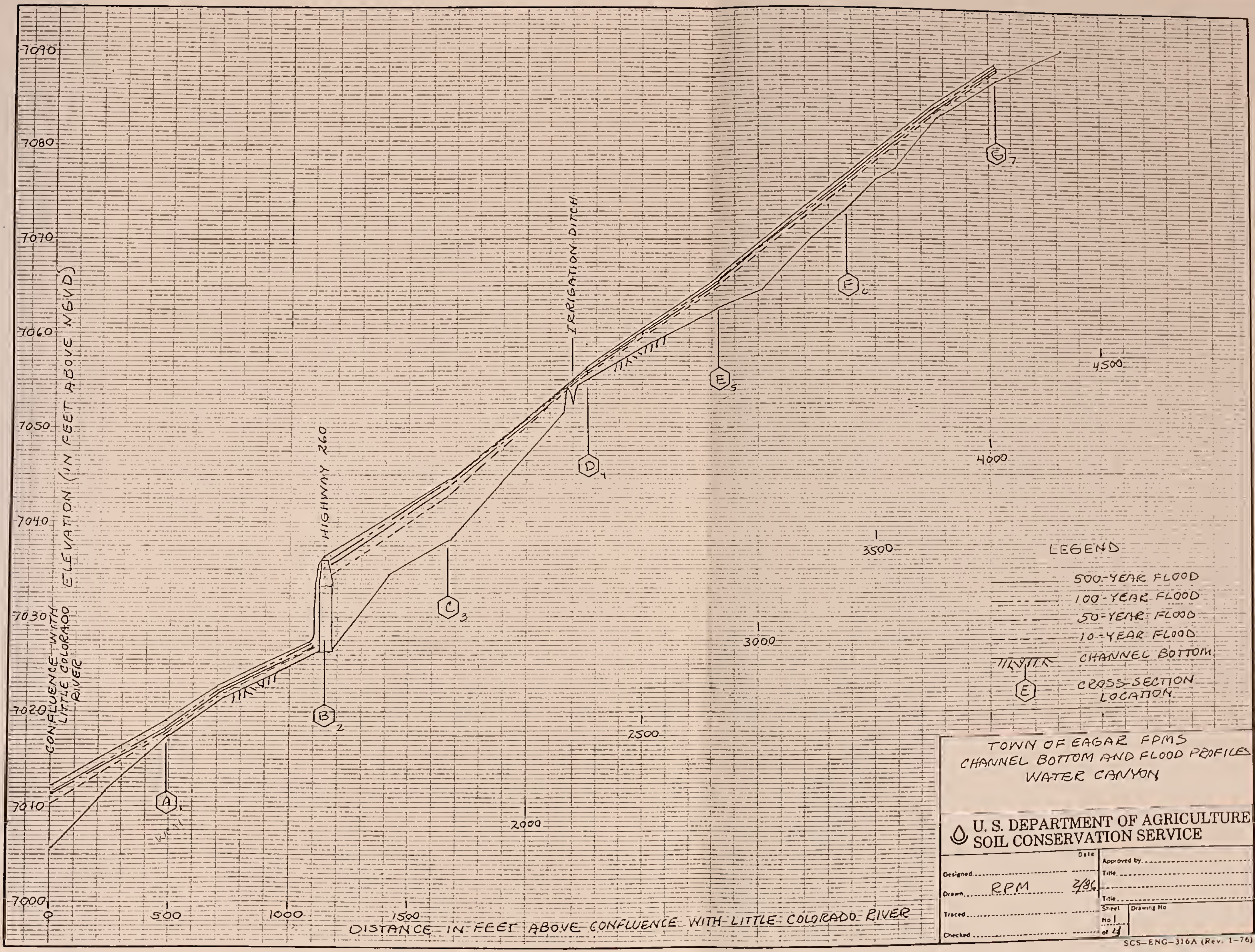

7090
7080
7070
7060
7050
7040
7030
7020
7010
7000
ELEVATION (IN FEET ABOVE NGVD)
CONFLUENCE WITH LITTLE COLORADO RIVER
HIGHWAY 260
IRRIGATION DITCH
A 1
B 2
C 3
D 4
E 5
F 6
G 7
0
500
1000
1500
2000
2500
3000
3500
4000
4500
DISTANCE IN FEET ABOVE CONFLUENCE WITH LITTLE COLORADO RIVER
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
CROSS-SECTION LOCATION
E
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
WATER CANYON
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Date
Designed
Drawn RPM 2/86
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Checked
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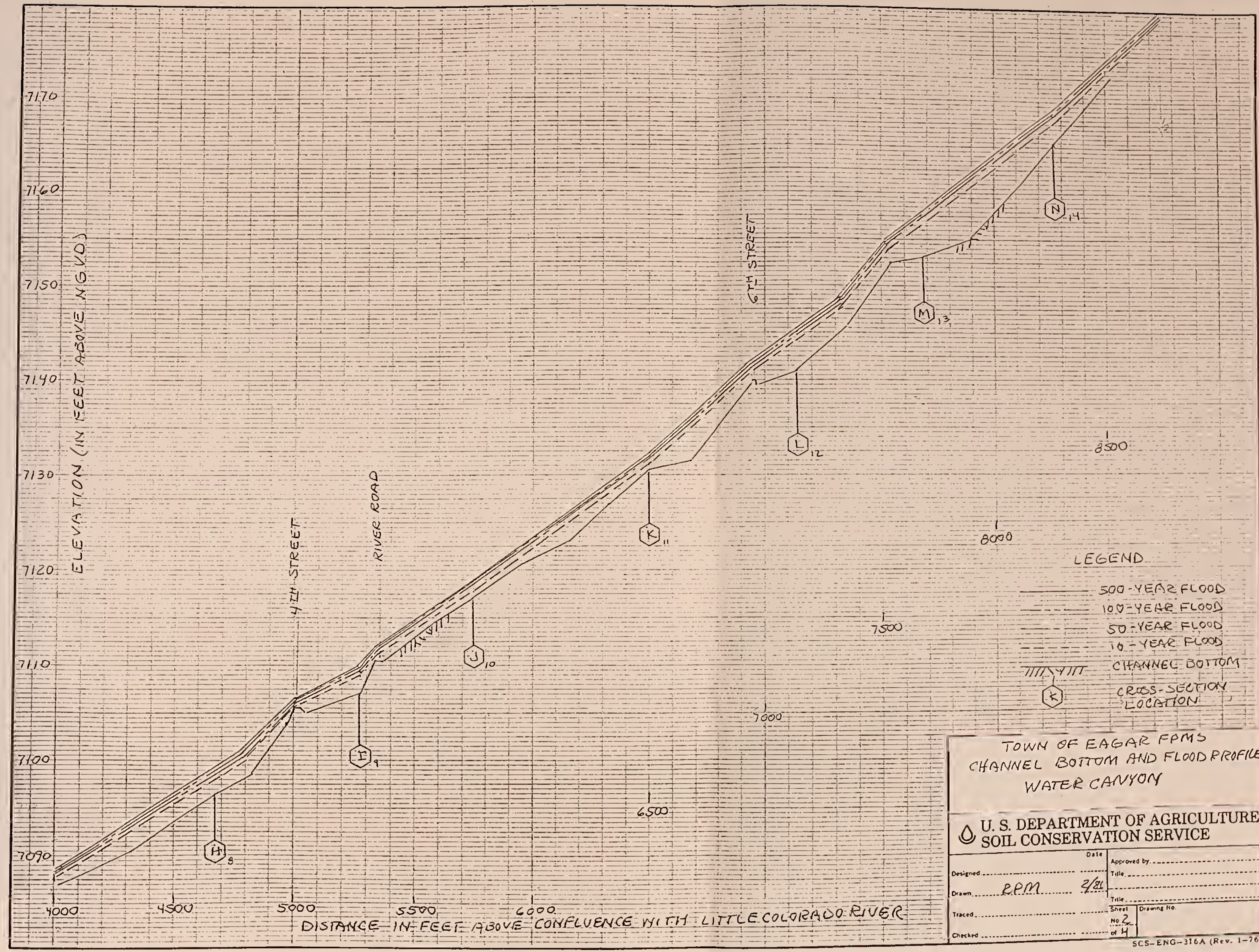
Title
Title
Sheet No 1 of 4
Drawing No
SCS-ENG-316A (Rev. 1-76)


ELEVATION (IN FEET ABOVE NGVD)
7170
7160
7150
7140
7130
7120
7110
7100
7090
4000
4500
5000
5500
6000
6500
7000
7500
8000
8500
DISTANCE IN FEET ABOVE CONFLUENCE WITH LITTLE COLORADO RIVER
4TH STREET
RIVER ROAD
6TH STREET
H 8
I 9
J 10
K 11
L 12
M 13
N 14
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
CROSS-SECTION LOCATION
K
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILE
WATER CANYON
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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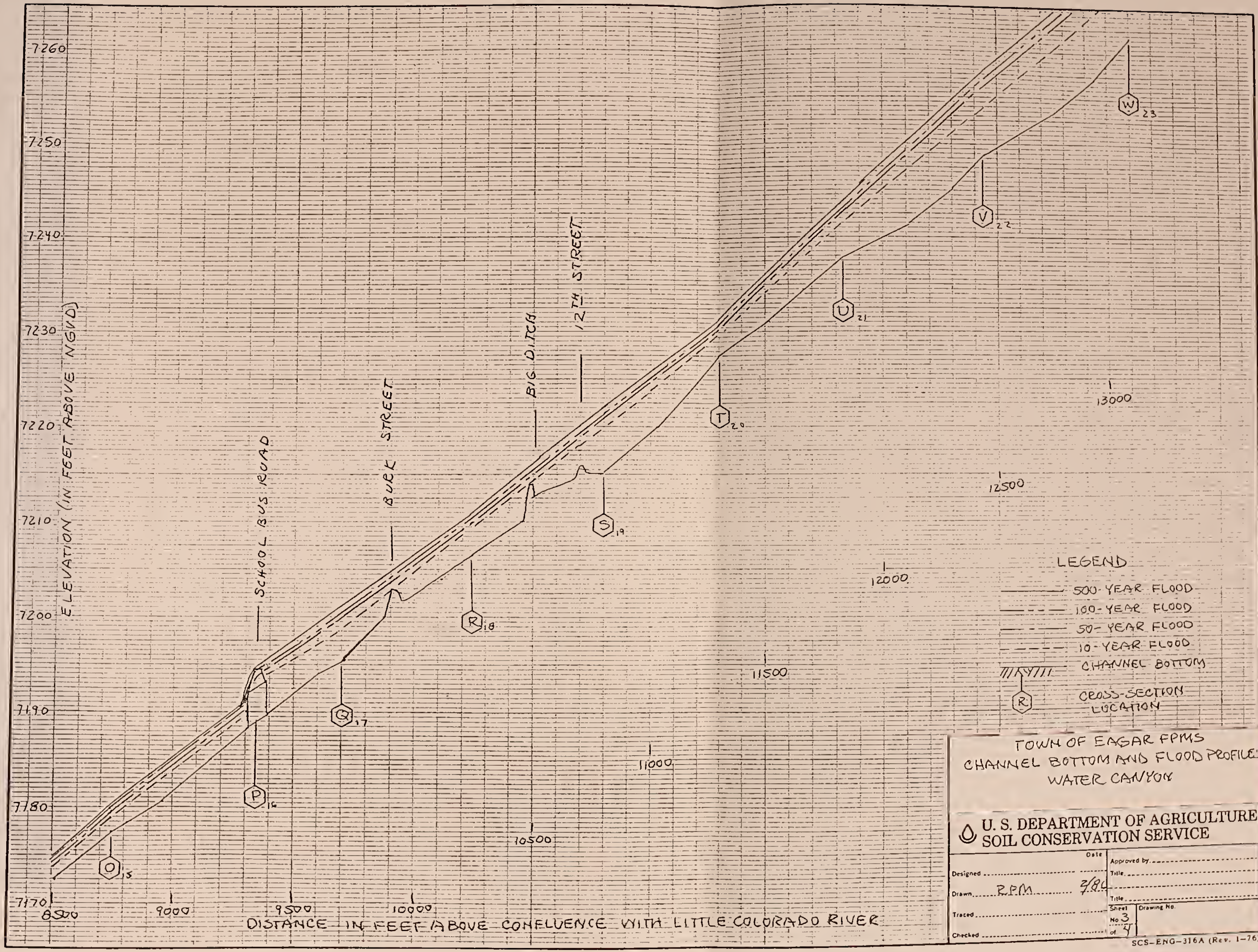

ELEVATION (IN FEET ABOVE NGVD)
7260
7250
7240
7230
7220
7210
7200
7190
7180
7170
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
DISTANCE IN FEET ABOVE CONFLUENCE WITH LITTLE COLORADO RIVER
SCHOOL BUS ROAD
BURK STREET
BIG DITCH
12TH STREET
O 15
P 16
Q 17
R 18
S 19
T 20
U 21
V 22
W 23
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
R
CROSS-SECTION LOCATION
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
WATER CANYON
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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Date
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Title
Sheet No 3 of 4
Drawing No.
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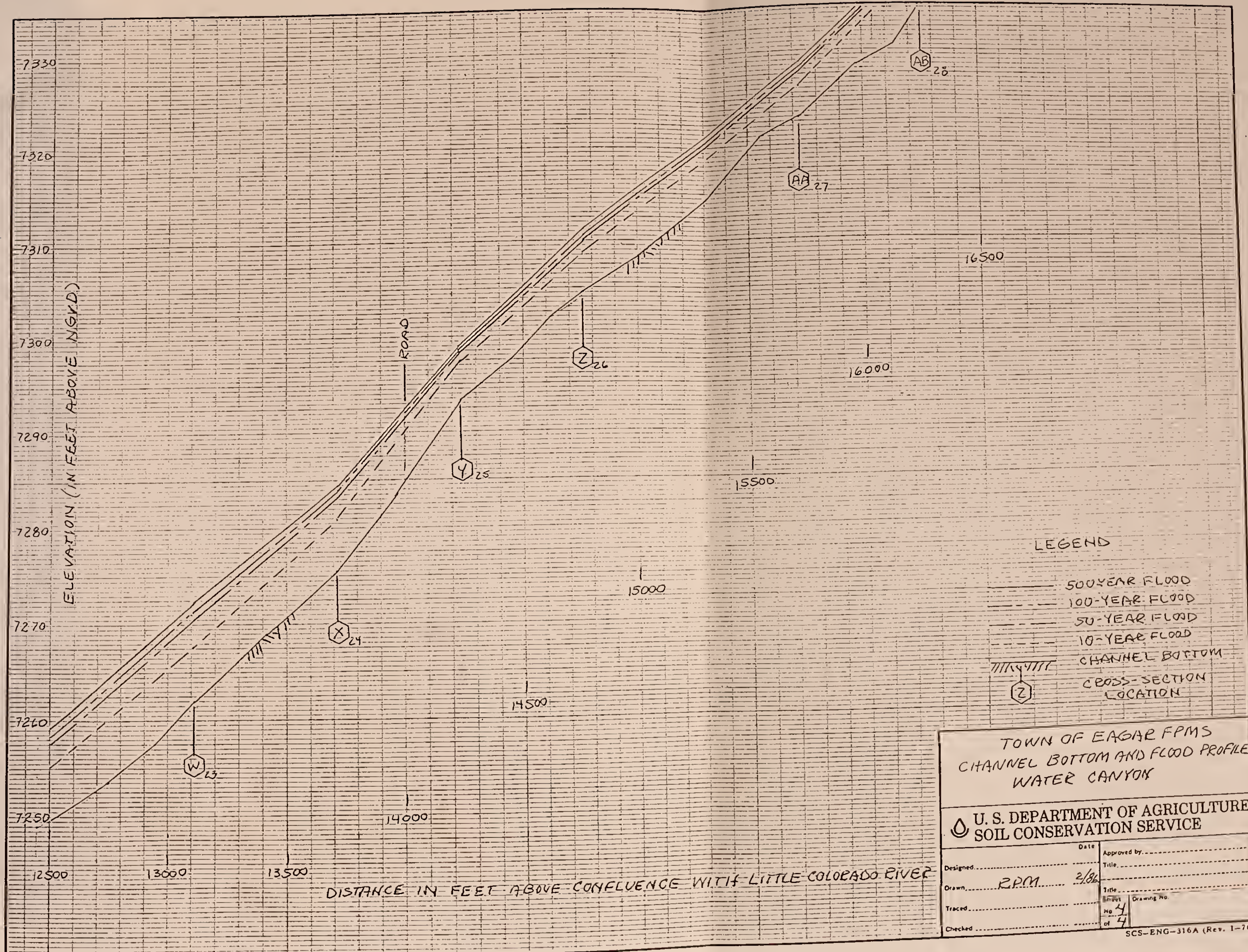
ELEVATION (IN FEET ABOVE N.G.V.D.)
7330
7320
7310
7300
7290
7280
7270
7260
7250
12500
13000
13500
14000
14500
15000
15500
16000
16500
ROAD
W 23
X 24
Y 25
Z 26
AA 27
AB 28
DISTANCE IN FEET ABOVE CONFLUENCE WITH LITTLE COLORADO RIVER
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
CROSS-SECTION LOCATION
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
WATER CANYON
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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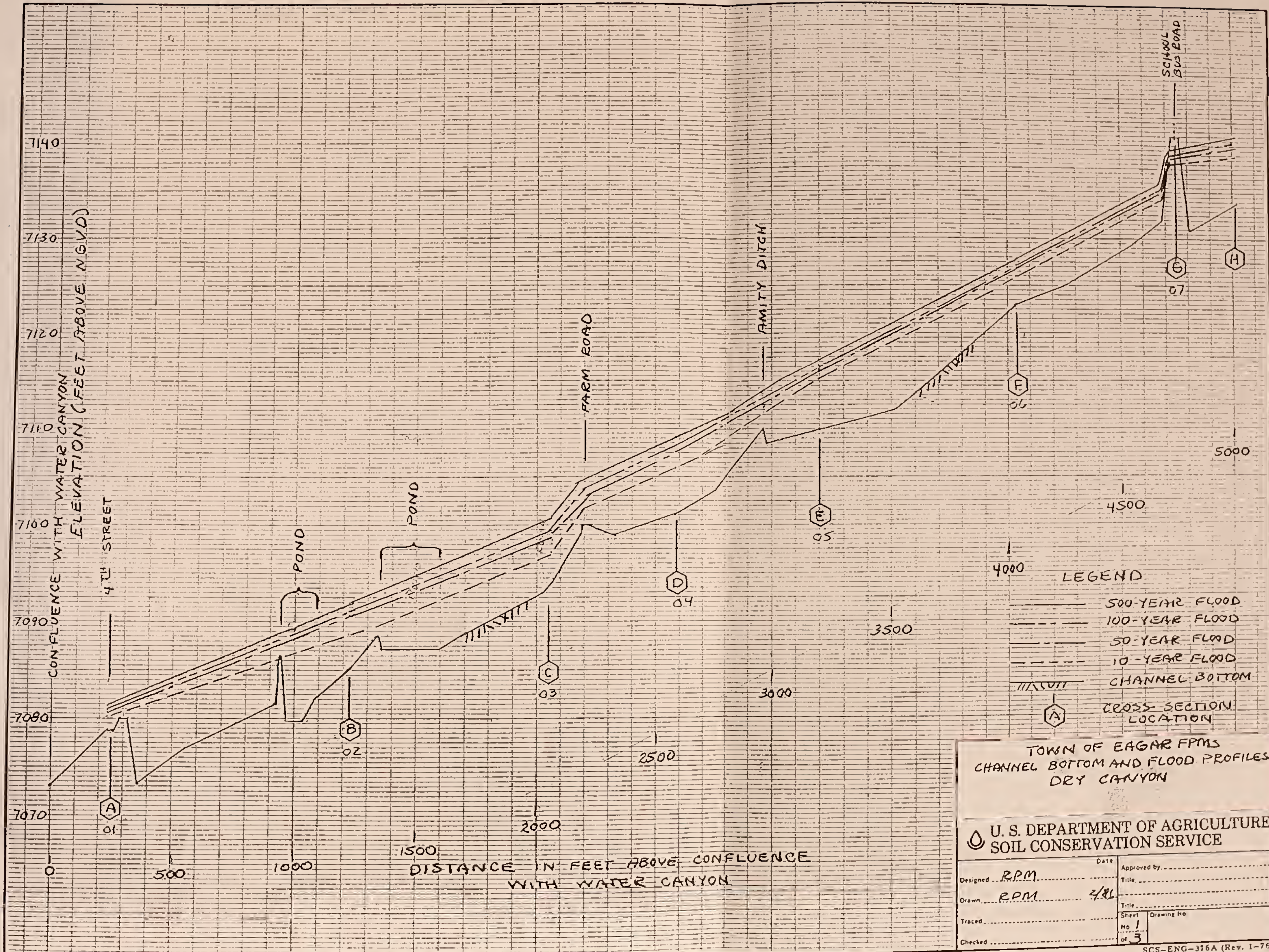
SCS-ENG-316A (Rev. 1-76)


ELEVATION (FEET ABOVE NGVD)
DISTANCE IN FEET ABOVE CONFLUENCE WITH WATER CANYON
7070
7080
7090
7100
7110
7120
7130
7140
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
CONFLUENCE WITH WATER CANYON
4TH STREET
POND
POND
FARM ROAD
AMITY DITCH
SCHOOL BUS ROAD
A 01
B 02
C 03
D 04
E 05
F 06
G 07
H
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
CROSS SECTION LOCATION
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
DRY CANYON
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed RPM
Drawn RPM
Date 2/81
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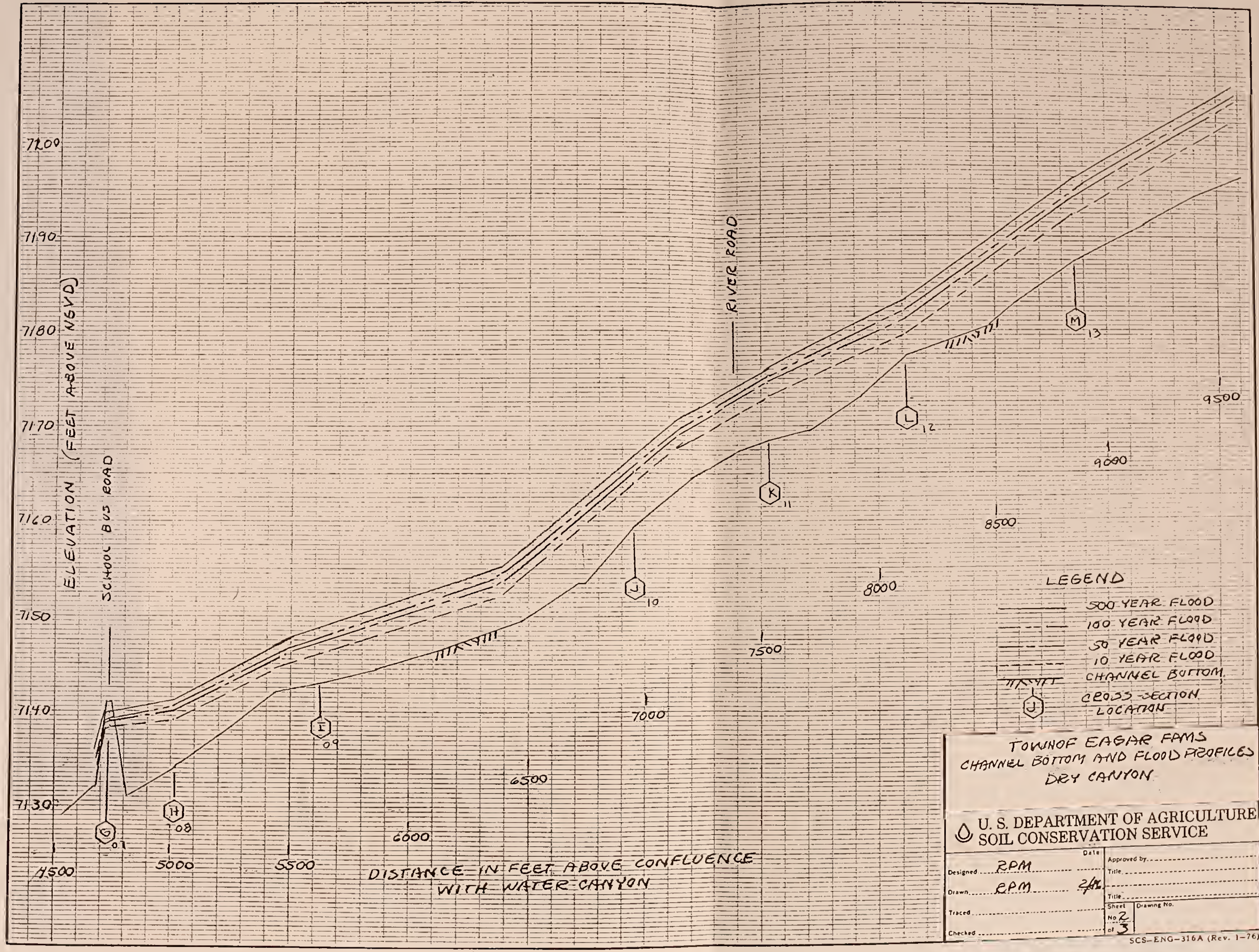
SCS-ENG-316A (Rev. 1-76)


ELEVATION (FEET ABOVE NGVD)
7130
7140
7150
7160
7170
7180
7190
7200
SCHOOL BUS ROAD
RIVER ROAD
G
07
H
08
I
09
J
10
K
11
L
12
M
13
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
9500
DISTANCE IN FEET ABOVE CONFLUENCE WITH WATER CANYON
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
CHANNEL BOTTOM
CROSS-SECTION LOCATION
TOWN OF EAGAR FAMS
CHANNEL BOTTOM AND FLOOD PROFILES
DRY CANYON
U. S. DEPARTMENT OF AGRICULTURE
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7th Street, between Butler and Cherry Avenue;
looking north. Approx. depth 1.2 ft.

7th Street, between Main Street and Eagar
Avenue; looking north. Approx. depth 0.7 ft.

Butler Avenue at 4th Street
Approx. depth 1.2 ft.

Butler Avenue near 3rd Street
Approx. depth 1.2 ft.

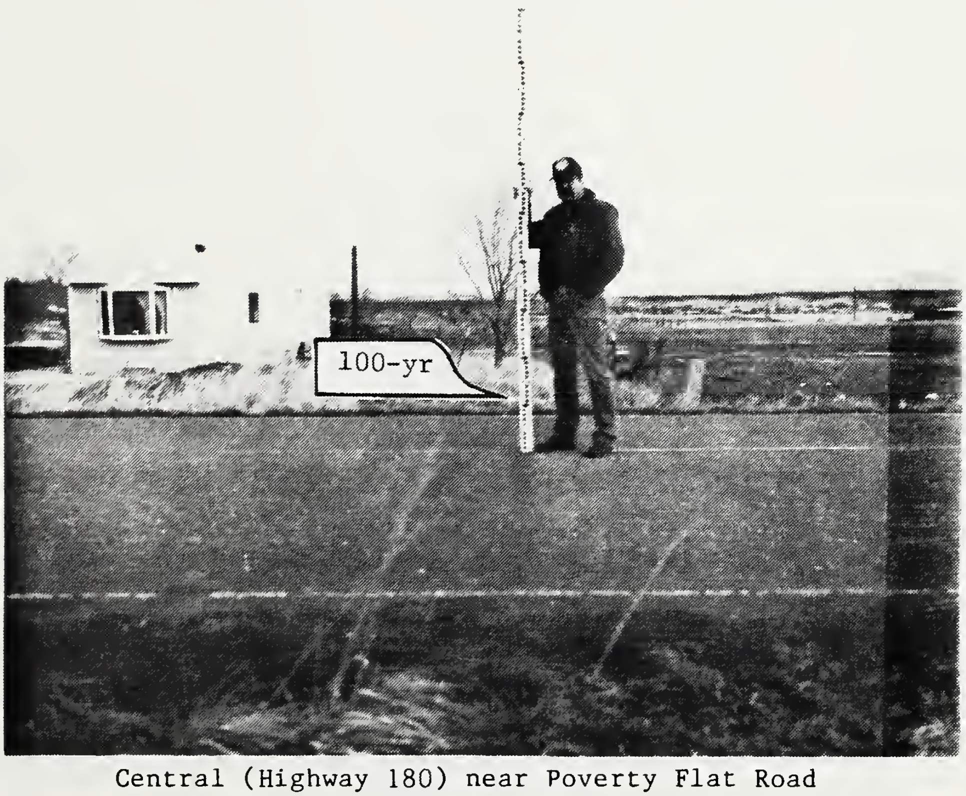
Central between Butler and Hamblin Avenues
Approx. depth 1.1 ft.

Central near Main Street
Approx. depth 1.0 ft.

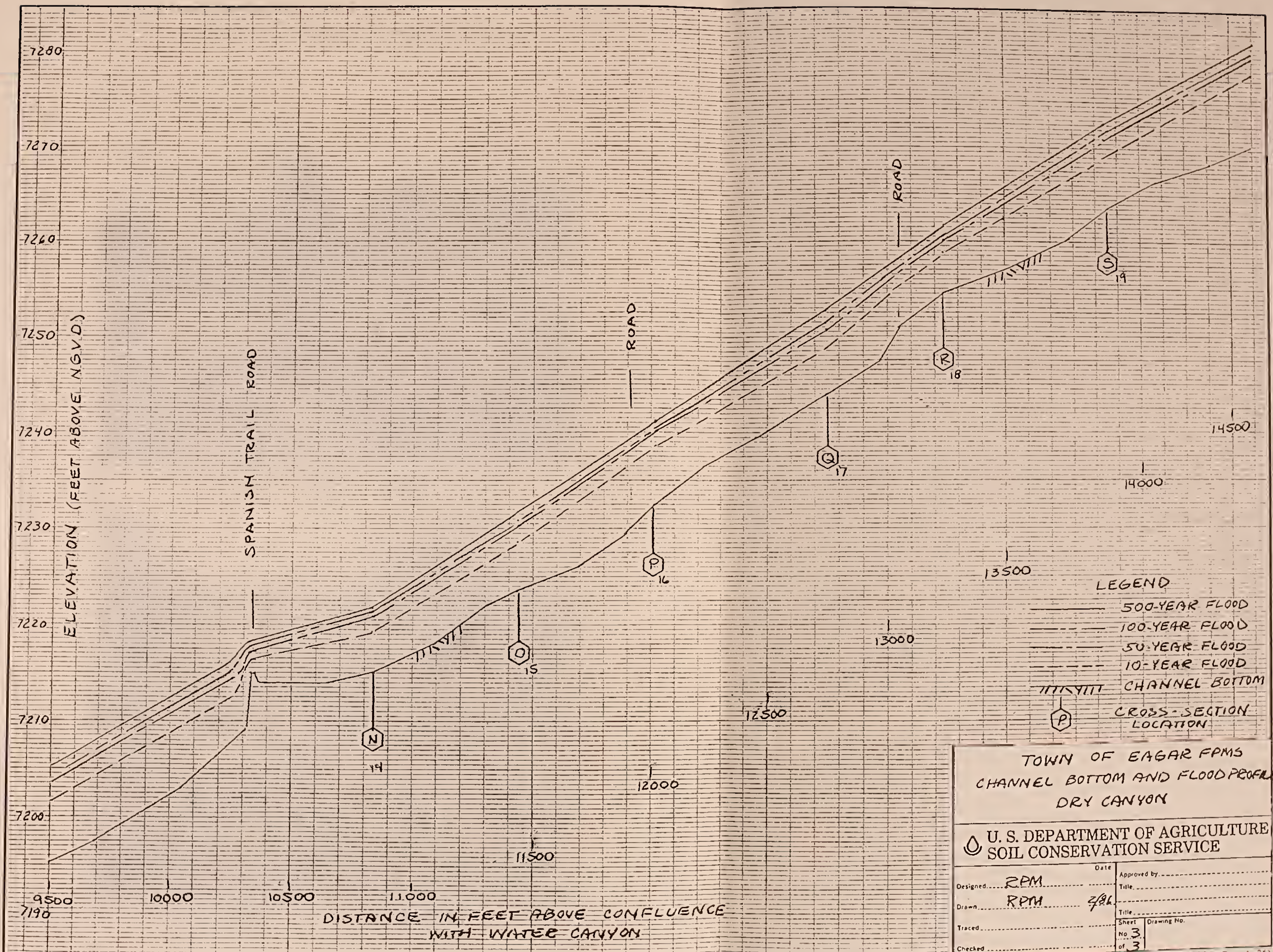
Main Street near 2nd Street
Approx. depth 1.0 ft.

Intersection of Burk and 12th Streets
Water Canyon
Approx. depth 1.2ft.

River Road near 4th Street; looking north-northeast; Water Canyon
Approx. depth 1.5 ft.



Central (Highway 180) near Poverty Flat Road
Robertson Hollow
Approx. depth 1.1 ft.



7280
7270
7260
7250
7240
7230
7220
7210
7200
7190
ELEVATION (FEET ABOVE N.G.V.D.)
SPANISH TRAIL ROAD
ROAD
ROAD
N
14
O
15
P
16
Q
17
R
18
S
19
9500
10000
10500
11000
11500
12000
12500
13000
13500
14000
14500
DISTANCE IN FEET ABOVE CONFLUENCE WITH WATER CANYON
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CHANNEL BOTTOM
P
CROSS-SECTION LOCATION
TOWN OF EAGAR FPMS
CHANNEL BOTTOM AND FLOOD PROFILES
DRY CANYON
U. S. DEPARTMENT OF AGRICULTURE
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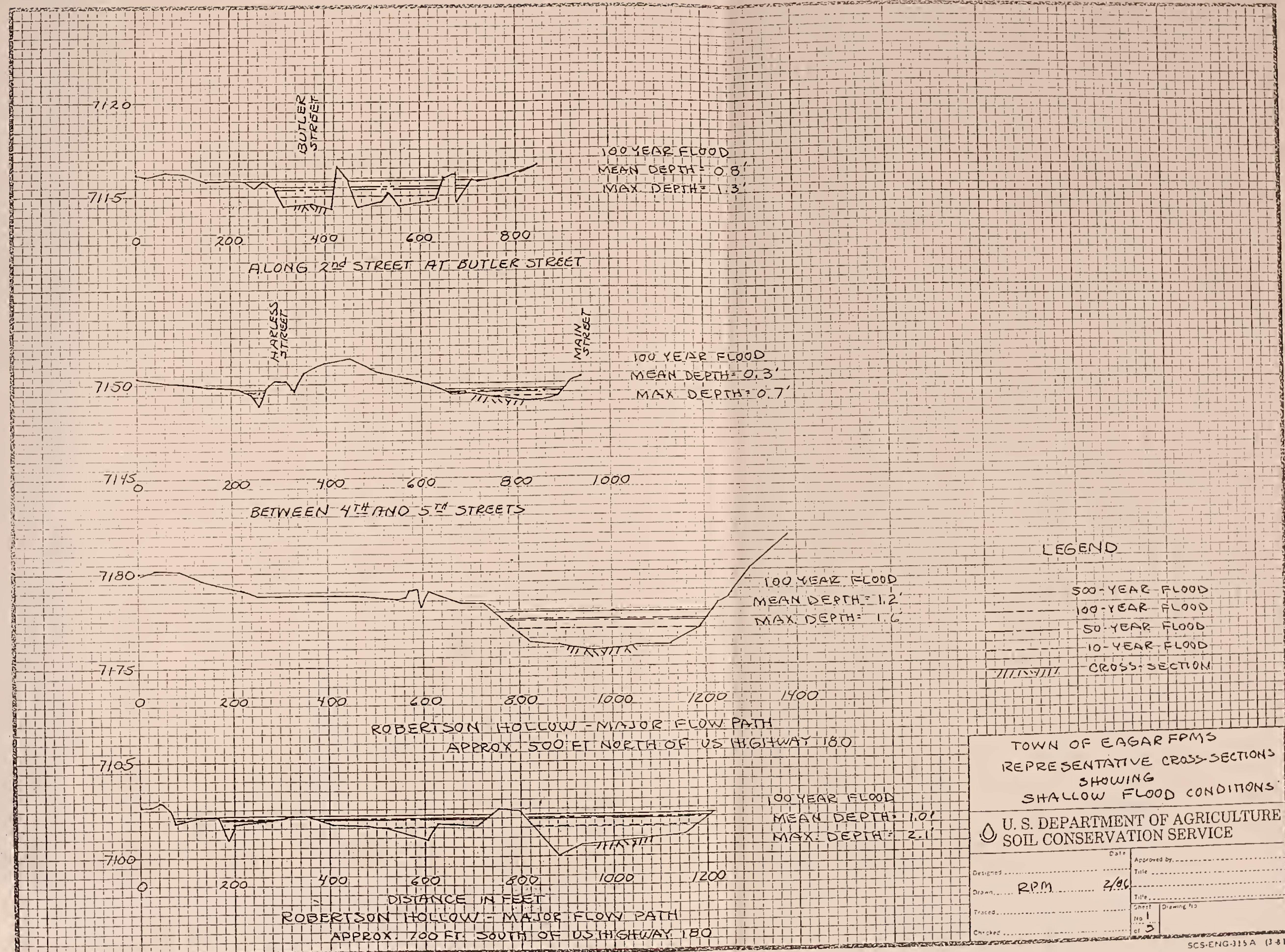

7120
7115
BUTLER STREET
100 YEAR FLOOD
MEAN DEPTH = 0.8'
MAX DEPTH = 1.3'
0
200
400
600
800
ALONG 2nd STREET AT BUTLER STREET
HARLESS STREET
MAIN STREET
100 YEAR FLOOD
MEAN DEPTH = 0.3'
MAX DEPTH = 0.7'
7150
7145
0
200
400
600
800
1000
BETWEEN 4TH AND 5TH STREETS
7180
7175
100 YEAR FLOOD
MEAN DEPTH = 1.2'
MAX DEPTH = 1.6'
0
200
400
600
800
1000
1200
1400
ROBERTSON HOLLOW - MAJOR FLOW PATH
APPROX. 500 FT NORTH OF US HIGHWAY 180
LEGEND
500-YEAR FLOOD
100-YEAR FLOOD
50-YEAR FLOOD
10-YEAR FLOOD
CROSS-SECTION
7105
7100
100 YEAR FLOOD
MEAN DEPTH = 1.0'
MAX DEPTH = 2.1'
0
200
400
600
800
1000
1200
DISTANCE IN FEET
ROBERTSON HOLLOW - MAJOR FLOW PATH
APPROX. 700 FT. SOUTH OF US HIGHWAY 180
TOWN OF EAGAR FPMS
REPRESENTATIVE CROSS-SECTIONS SHOWING SHALLOW FLOOD CONDITIONS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
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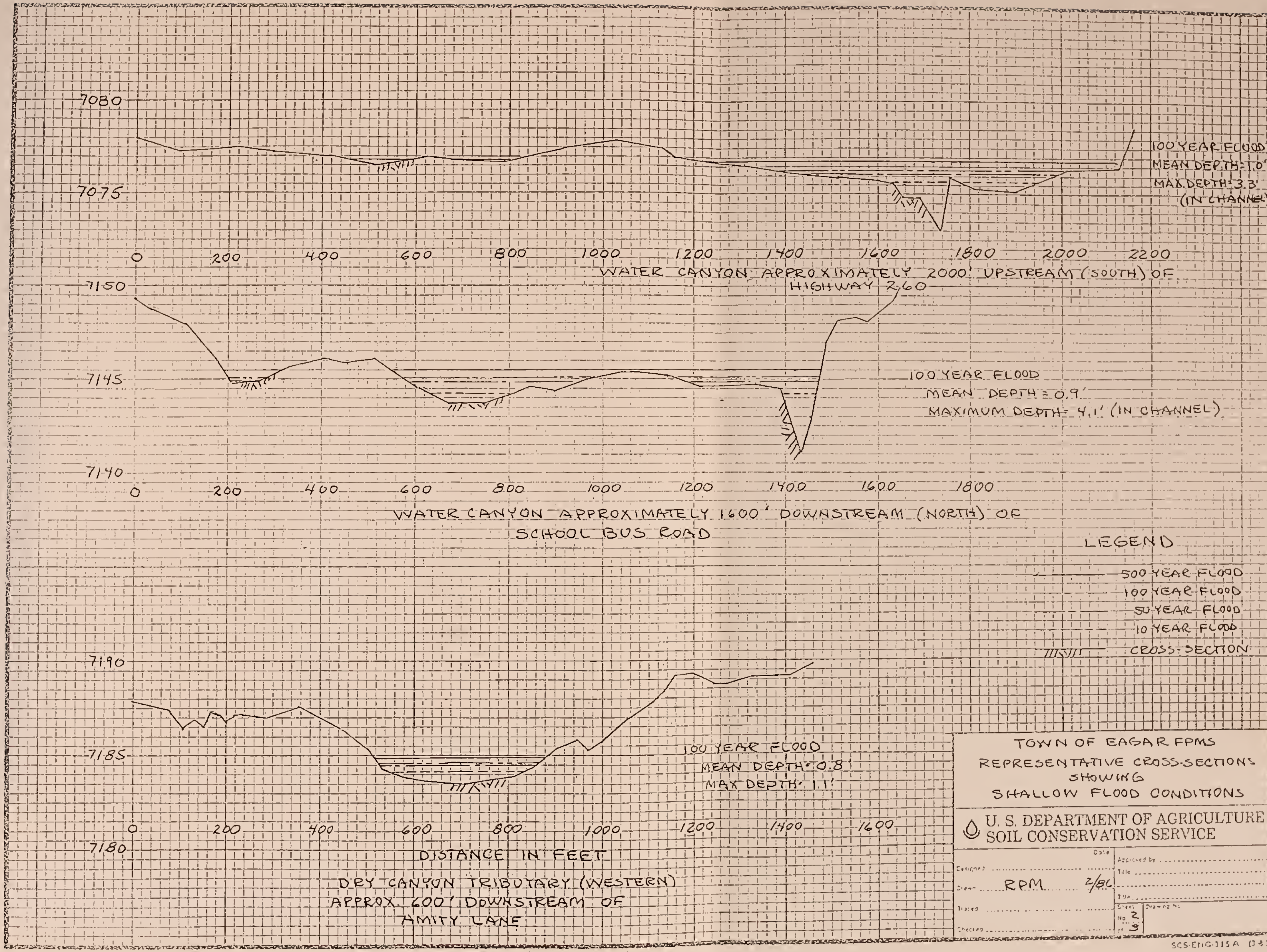
Drawing No.
SCS-ENG-315A (3-81)


7080
7075
100 YEAR FLOOD
MEAN DEPTH: 1.0'
MAX.DEPTH: 3.3'
(IN CHANNEL)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200
WATER CANYON APPROXIMATELY 2000' UPSTREAM (SOUTH) OF HIGHWAY 260
7150
7145
7140
100 YEAR FLOOD
MEAN DEPTH = 0.9'
MAXIMUM DEPTH = 4.1' (IN CHANNEL)
0 200 400 600 800 1000 1200 1400 1600 1800
WATER CANYON APPROXIMATELY 1600' DOWNSTREAM (NORTH) OF SCHOOL BUS ROAD
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
CROSS-SECTION
7190
7185
7180
100 YEAR FLOOD
MEAN DEPTH: 0.8'
MAX DEPTH: 1.1'
0 200 400 600 800 1000 1200 1400 1600
DISTANCE IN FEET
DRY CANYON TRIBUTARY (WESTERN)
APPROX. 600' DOWNSTREAM OF AMITY LANE
TOWN OF EAGAR FPMS
REPRESENTATIVE CROSS-SECTIONS SHOWING SHALLOW FLOOD CONDITIONS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
RPM 2/80
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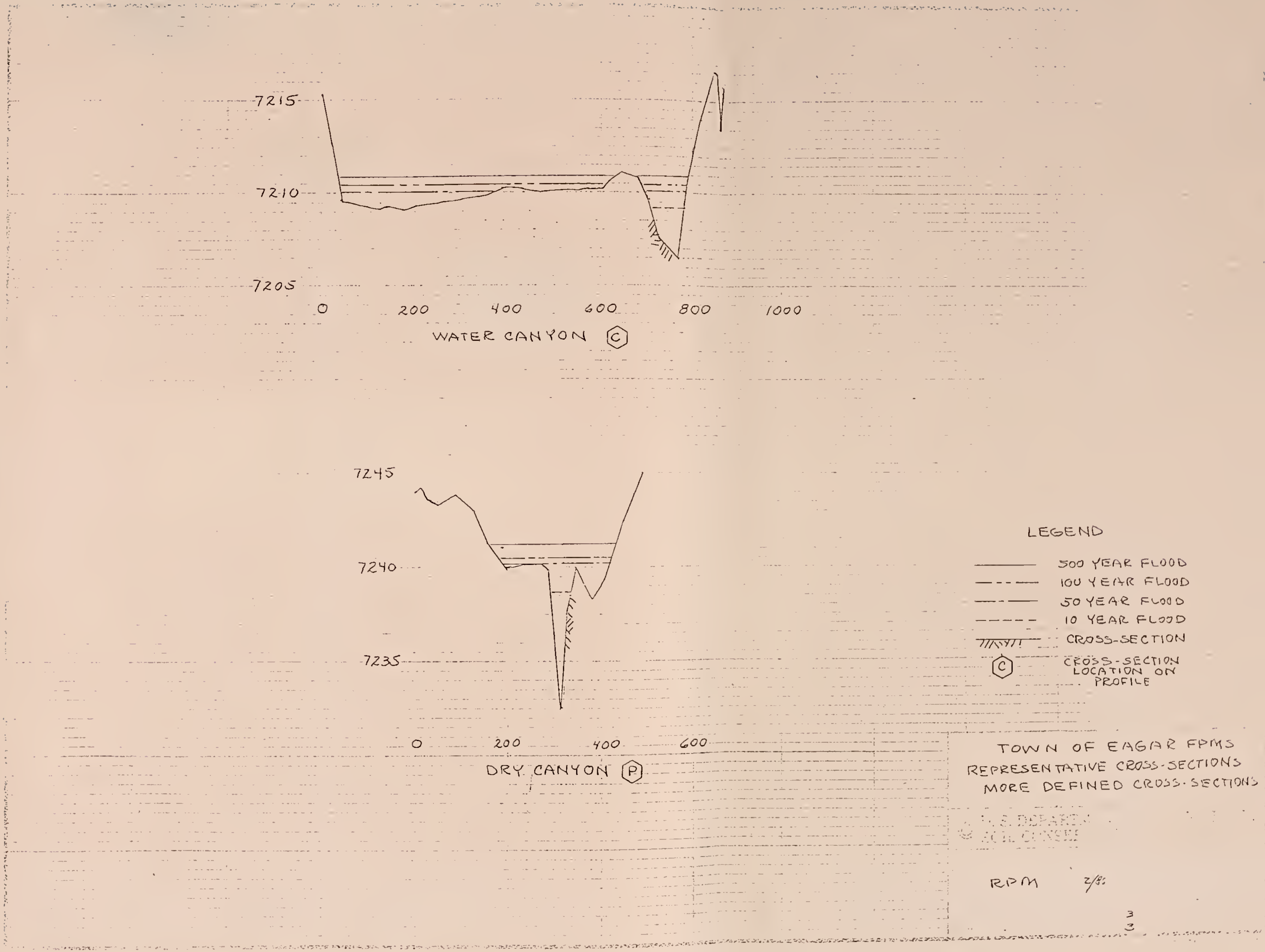
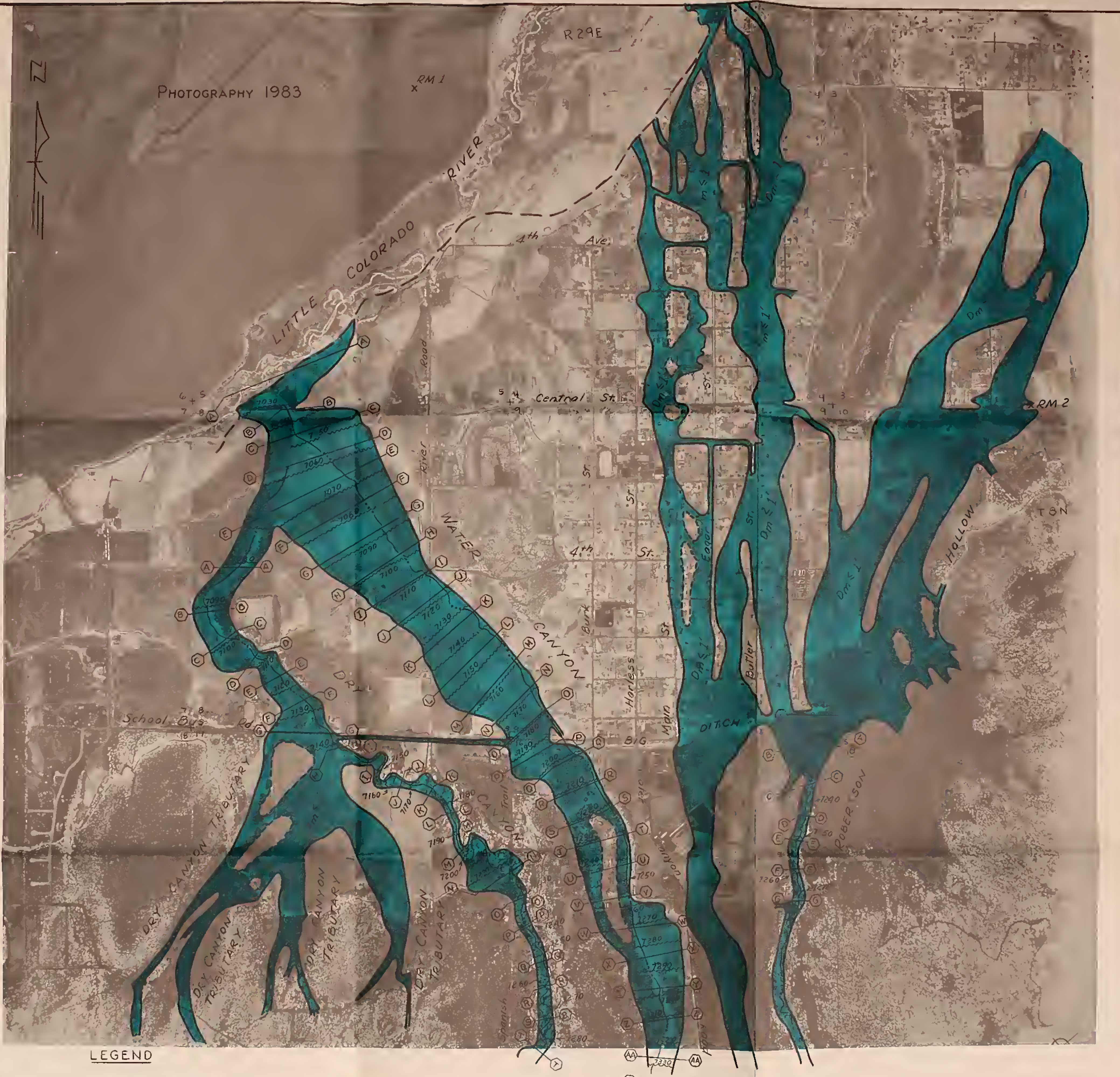
SCS-ENG-315A



7215
7210
7205
0
200
400
600
800
1000
WATER CANYON C
7245
7240
7235
0
200
400
600
DRY CANYON P
LEGEND
500 YEAR FLOOD
100 YEAR FLOOD
50 YEAR FLOOD
10 YEAR FLOOD
CROSS-SECTION
C
CROSS-SECTION LOCATION ON PROFILE
TOWN OF EAGAR FPMS
REPRESENTATIVE CROSS-SECTIONS
MORE DEFINED CROSS-SECTIONS
RPM



LEGEND

× RM 2	Elevation Reference Mark
Ⓐ——Ⓐ	Cross Section Line
7100	100 Year Flood Elevation Line; Elevation In Feet Above NGVD
$D_m \leq 1'$	Average Depth Equal Or Less Than One Foot
(shaded)	Inundated Area 100 Year Flood

Note: Map Was Prepared To Provide Minimum Flood Plain Management Information; It May Not Show All Areas Subject To Flooding In The Community.

ELEVATION REFERENCE MARKS

Reference Mark	Elevation (Ft. NGVD)	Description of Location
RM 1	7036.73	U.S. Geological Survey 2.5 inch Brass Cap located 1200 feet north of 5 foot Fence, 2000 feet southeast of Airport Hangar, on Open Field, projecting 0.8 foot
RM 2	7091.64	Cellar Borr Assoc. PK. Nail set in Center Line of Road; 6000 feet west of Rodeo Ground; on US 180; 1700 feet west of Section Corner 2,3,10,11; Twp 8 N; R 29 E.

TOWN OF EAGAR
FLOOD PLAIN MANAGEMENT STUDY

FLOOD HAZARD MAP
100 YEAR FLOOD

1000 0 1000
SCALE IN FEET

JUNE 1986

PREPARED BY THE
SOIL CONSERVATION SERVICE - USDA

MAPPING UNITS

① Urban/Industrial Area
② Urban/Rural Scattered/Mixed
③ Irrigated/Subirrigated Pastures/Cropland
④ Pinyon-Juniper Dry Washes
⑤ Riparian, Watercourses and Wet Areas
⑥ Blue Grama-Juniper Mixed Grasslands
⑦ Pinyon-Juniper Uplands
▨ Prime Farmland

TOWN OF EAGAR
FLOOD PLAIN MANAGEMENT STUDY
INVENTORY OF NATURAL VALUES
PRIME FARMLAND
AND
MAPPING UNITS USED TO DESCRIBE
WILDLIFE RESOURCES

1000 0 1000
SCALE IN FEET (APPROX.)

JUNE 1986